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Description

SYSTEM AND METHOD TO QUALIFY A LINE PAIR

FIELD OF THE INVENTION

[0001] The present invention relates to high bit-rate, complex communications, such as high bit-rate digital subscriber line (DSL) technologies (ADSL, ADSL2+, HDSL2, G.SHDL) and the like, and more particularly to a system and method to qualify a line pair for such services or similar services.

BACKGROUND OF INVENTION

[0002] High performance or high bit-rate (about 1.536Mbps or higher) communication services, such as complex DSL technologies and the like, are typically being deployed over standard telephone local loops or copper line pairs originally designed for voice telecommunication services and are being expected to "get the most out of a loop." These technologies rely heavily on error correction, complex modulation schemes, scrambling and other adaptive

techniques to carry close to the theoretical maximum traffic on a local loop. These complex DSL technologies may be serving mission critical applications. Not just someone surfing the Internet. HDSL and increasingly, ADSL are being used by businesses for day-to-day operations, e-commerce and the like and therefore have demanding uptime requirements. Circuit downtime may be a minimum of about a thirty second event. The adaptive nature of the modems used in such circuits or communication systems means there may be about a thirty second training period if a link fails for the modem to recharacterize the line. This may be a significant outage and may cause some telephone or data systems to go into an alarm status. Accordingly, full copper or line qualification testing may be paramount to achieving the reliability from such systems.

[0003] Testing and qualifying these line pairs can require at least two technicians or multiple trips by a single technician between a subscriber's or customer's premises and a serving telephone switching office or central office. One technician with a test set may be located at the subscriber's premises. The other technician may be located at the serving telephone central office to attach a portable

tester, such as a far-end device (FED) or the like to the line pair. The FED may operate in coordination with the one technician's test set to apply different types of terminations to the line pair to test and qualify the line pair for xDSL service or similar service. Under some circumstances, where the telephone central office may be manned, the cooperation of a frame attendant or other personnel at the telephone central office may be employed. Although, this arrangement can be time consuming and inefficient because of delays waiting for assistance from the central office personnel who may not have the proper equipment and may be busy with other demands. Alternatively, a technician can visit the telephone central office to install the portable tester, FED or the like.

[0004] Therefore, line testing and qualifying or copper testing and qualifying can be labor intensive and costly. With profit margins for some xDSL services declining, some service providers have opted not to perform line qualification testing. Additionally, some modems used for xDSL service have been touted to be able to detect faults on the line pair that may lead to future system failures. Such modems may be able to effectively quantify random errors but may fail to detect faults that can make the line pair

susceptible to non-random events, such as imbalance and other impairments.

[0005] Accordingly, there is a need to provide a method and system to qualify a line pair that is efficient, cost effective and only requires a single technician. There is also a need to provide a test set with a modem that is capable of instructing or sending signals to an HTU or modem at another end of the line pair to perform line pair qualification testing.

SUMMARY OF INVENTION

[0006] In accordance with an embodiment of the present invention, a method to qualify a line pair may include sending an initiate test signal to a central office termination unit (HTU-C) or modem. A series of line pair qualifying tests may be performed in response to the initiate test signal, wherein the HTU-C or modem may be adapted to provide selected types of terminations connectable to the line pair to perform the qualifying tests.

[0007] In accordance with another embodiment of the present invention, a method to qualify a line pair may include coupling a test set adapted to perform a series of qualification tests to a line pair. The method may also include using a terminating unit (HTU) or modem as a far-end de-

vice to perform the series of qualification tests in coordination with the test set.

[0008] In accordance with another embodiment of the present invention, a method to qualify a line pair may include coupling a far end device to the line pair to perform selected line qualification tests. The method may also include coupling a termination unit to the line pair by the far end device to perform other selected line qualification test.

[0009] In accordance with another embodiment of the present invention, a system to qualify a line pair may include a test set adapted to perform a series of qualification tests on the line pair. The system may also include a terminating unit (HTU) or modem that may be adapted to selectively provide different types of terminations connectable to the line pair to perform the series of qualifying tests on the line pair.

[0010] In accordance with another embodiment of the present invention, a system to qualify a line pair may include a far end device to perform line qualification tests and a termination unit. The far end device may be adapted or programmed to connect the termination unit to the line pair to perform the line qualifications tests.

[0011] In accordance with another embodiment of the present in-

vention, a termination unit (HTU) or modem may include a set of switches. The HTU or modem may also include a microprocessor to operate the switches to selectively connect different types of terminations to a line pair to perform qualifying tests on the line pair.

[0012] In accordance with another embodiment of the present invention, a test set to qualify a line pair may include a microprocessor to perform line qualification tests. An xDSL type modem may be included to signal a termination unit (HTU) or modem to selectively connect different types of terminations to the line pair to perform the line qualifying tests.

[0013] In accordance with another embodiment of the present invention, a method of making a termination unit (HTU) or modem may include providing a microprocessor; and providing instructions executable by the microprocessor to perform line qualification tests on a line pair.

Brief Description of Drawings

[0014] Figure 1 is a block diagram of a system to qualify a line pair in accordance with an embodiment of the present invention.

[0015] Figure 2 is a block diagram of a system to qualify a line pair in accordance with another embodiment of the

present invention.

[0016] Figure 3 is a block diagram of a system to qualify a line pair in accordance with another embodiment of the present invention.

[0017] Figure 4 is flow chart of a method to qualify a line pair in accordance with an embodiment of the present invention.

[0018] Figure 5 is a flow chart of a method to qualify a line pair in accordance with another embodiment of the present invention.

[0019] Figure 6 is a flow chart of a method to qualify a line pair in accordance with a further embodiment of the present invention.

DESCRIPTION OF INVENTION

[0020] The following detailed description of preferred embodiments refers to the accompanying drawings that illustrate specific embodiments of the invention. Other embodiments having different structures and operations do not depart from the scope of the present invention.

[0021] Figure 1 is a block diagram of a system 100 to qualify a line pair or pairs 102 for xDSL service or similar communication service in accordance with an embodiment of the present invention. The system 100 may include a central office termination unit (HTU-C) 104, modem or the like

located at a telephone switching office 106 or central office. The HTU-C 104 or modem may be adapted to selectively provide different types of terminations connectable to the line pair 102 to perform qualifying tests on the line pair 102 for xDSL or similar service. The HTU-C 104 may include a microprocessor 108, controller or similar device. The HTU-C 104 may also include a memory 110 that may contain software or stored computer programs that may be executed by the microprocessor 104 to control operation of the HTU-C 104 including performance of line qualification tests. The memory 110 may be part of the microprocessor 104 or a separate component.

[0022] The HTU-C 104 may also include a set of switches 112 and 114, relays or similar devices. The microprocessor 108 may operate the switches 112 and 114 in response to receiving predetermined signals to selectively connect different types of terminations, such as an open circuit, a short circuit and a selected signal or the like, to the line pair 102 for line qualification or copper qualification testing. A first set of switches 112 may connect the line pair 102 to a transformer 116. Accordingly, the microprocessor 108 may operate the switches 112 to an open position, as shown in Figure 1, to provide an open circuit ter-

mination to the line pair 102. The open circuit termination may be provided for a predetermined time period or in response to the HTU-C 104 receiving a first predetermined signal for performance of open circuit line qualifying tests, as will be described in more detail below. Alternatively, the microprocessor 108 may operate the switches 112 to a closed position to connect the line pair 102 to the transformer 116 and thereby provide a short circuit termination to the line pair 102. The short circuit termination may be coupled to the line pair 102 for a predetermined time period or in response to the HTU-C 104 receiving a second predetermined signal for performance of short circuit line qualifying tests, as described in more detail below.

[0023] The transformer 116 may be connectable to a signal source 118 by a second switch 114, relay or similar device. The signal source 118 may be the source of a signal with known characteristics for measuring or performing signal loop line qualification tests on the line pair 102. The microprocessor 104 may operate switches 112 and switch 114 to couple the signal source termination 118 to the line pair 102. The signal source termination 118 may be coupled to the line pair 102 for a predetermined time

period or in response to the HTU-C 104 receiving a third predetermined signal for performing signal loop line qualification tests as described in more detail below.

[0024] The system 100 may also include a test set 120 that may be used at a customer's or subscriber's premises 122. The test set 120 may be an Acterna® model HST-3000™ handheld outside plant tester as manufactured by the Acterna Corporation, Germantown, MD, or a similar type testing device. The test set 120 may include a microprocessor (MP) 124 to control operation of the test set 120 and to perform different tests, such as line qualification tests on line pair 102. The test set 120 may also include a memory 126 to store software (SW) or computer programs for operation of the test set 120. The memory 126 may also store application programs to perform specific functions or tests. For example, line or copper qualification tests that may include generating predetermined signals to instruct the HTU-C 104 to initiate the line qualification tests or to connect a selected termination to the line pair 102 in response to receiving each of the predetermined signals. The memory 126 may also store results of different line qualification tests or results of other types of tests. The test set 120 may also include a display 128 and

keypad (KP) 130 for a user or technician to interface with the test set 120 and control the test set's operation. The test set 120 may be connected to the line pair 102 by a set of switches 132, relays, jacks or similar devices.

[0025] The test set 120 may be connected to a remote termination unit (HTU-R) 134. The test set 120 may be connected to a craft terminal interface 136 of the HTU-R 134 by a video terminal 100 (VT100) emulation represented by reference numeral 138. The test set 120 may communicate with the HTU-C 104 through the HTU-R 134 and over a digital subscriber line (xDSL) link, such as an embedded operations channel (EOC) or the like, as represented by the broken or dashed line 140 in Figure 1. The EOC 140 may reside on the line pair 102. In an alternate embodiment, the test set 120 may communicate or send signals to the HTU-C 104 via a non-DSL link, such as analog signals or the like over the line pair 102.

[0026] The HTU-R 134 may include a microprocessor 142, controller or similar apparatus to control operation of the HTU-R 134. A memory 144 or storage device may be associated with the microprocessor 142 to store software (SW) or computer programs to be executed by the microprocessor 142 for operation of the HTU-R 134. The mem-

ory 144 or storage device may be incorporated as part of the microprocessor 142, as shown in Figure 1, or may be a separate component. The HTU-R 134 may also include a transformer 146. The transformer 146 may be coupled to the line pair 102 by a set of switches 148, relays or the like, under control of the microprocessor 142. The HTU-R 134 may be connected to the line pair 102 for the test set 120 to send signals to the HTU-C 104 over the xDSL link or EOC 140 to conduct the line qualification tests or other tests. The HTU-R 134 may be automatically disconnected from the line pair 102 by the switches 148 under control of the microprocessor 142 as instructed by the test set 120. The test set 120 may be automatically connected to the line pair 102 by the switches 132 to conduct the desired line qualification tests.

[0027] In one embodiment of the present invention, the switches 148 and 132 may be automatically operated to alternately connect and disconnect the HTU-R 134 and the test set 120 to the line pair 102 to conduct the line qualification tests. For example, the test set 120 may be coupled to the HTU-C 104 by the HTU-R 134 to send a predetermined signal to the HTU-C 104 via the xDSL link or EOC 140 for the HTU-C 104 to connect a selected termination to the

line pair 102. After sending the predetermined signal, the switches 148 may be automatically operated to disconnect the HTU-R 134 from the line pair 102. The switches 132 may be automatically operated to connect the test set 120 to the line pair 102 to perform a selected one of a plurality of line qualification tests. Alternately connecting and disconnecting the HTU-R 134 and the test set 120 to the line pair 102 may be repeated to instruct the HTU-C 104 to couple different terminations to the line pair 102 while the test set 120 performs different ones of the plurality of line qualification tests. In another embodiment, the switches 148 and 132 may be manually operated or operated by a technician entering an instruction or code into the keypad 130 of the test set 120. Accordingly, the present invention permits a line pair or pairs, such as line pairs 102, to be tested by a single technician from the customer's premises 122.

[0028] While the present invention has been described with respect to the test set 120 testing the line pair 102 from the customer premises 122, the test set 120 could also test the line pair 102 from the switching office 106. In this embodiment, the HTU-R 134 or modem may be modified to apply the different types of terminations to the line pair

for the line qualification testing. The HTU-R 134 may be modified to include a signal source 150 connectable to the transformer 146 by a switch 152, relay or the like. The signal source 150 and switch 152 are shown in dashed or broken lines in Figure 1 to illustrate that these components may form another embodiment of the present invention. The software 144 of the HTU-R 134 may also be modified to control the operation of the HTU-R 134 to connect different types of terminations to the line pair 102 similar to that described above with respect to HTU-C 104 to conduct the qualification testing. Accordingly, the present invention permits a line pair or pairs to be tested by a single technician, and in one embodiment of the present invention, line qualification testing can be done from the telephone or central office 106 without a technician being required to visit the customer premises 122.

[0029] Figure 2 is a block diagram of a system 200 to qualify a line pair 202 in accordance with another embodiment of the present invention. The system 200 may be similar to the system 100 of Figure 1. However, the system 200 may include an xDSL type modem 203 or a similar apparatus associated with the test set 220. The xDSL type modem 203 may be used in place of a remote termination unit

(HTU-R) 234 to communicate or send signals to a central office termination unit (HTU-C) 204 or modem in a telephone switching or central office 206 for performing the line qualification tests. The xDSL type modem 203 may be integrated into the test set 220 or may be a separate component.

[0030] The HTU-C 204 may include a microprocessor 208, controller or similar device to control operation of the HTU-C 204. A memory 210 or storage device may be associated with the HTU-C 204 to store software or computer executable code or programs for execution by the microprocessor 208 to carry out various functions that may include performing the line qualification tests in coordination with the test set 220. The HTU-C 204 may include a set of switches 212 and 214 or similar devices that may be controlled by the microprocessor 208 to couple different types of terminations to the line pair 202 for different line qualification tests. A first set of switches 212 may couple the line pair 202 to a transformer 216. The switches 212 and 214 may then be operated under control of the microprocessor 204 to connect different types of terminations to the line pair 202 for line qualification testing similar to that described with respect to Figure 1.

[0031] The test set 220 may include a microprocessor 224, controller or the like to control operation of the test set 220. The test set 220 may also include a memory 226 or storage device to store software or computer executable instructions or programs that may be executed by the microprocessor 224 to perform the line qualification tests and other functions. The test set 220 may further include a display 228 and keypad 230 for a technician to interface with the test set 220 and control the test set's operation. As previously discussed, an xDSL type modem 203 may be associated with the test set 220 as a separate component or integrated into the test set 220. The modem 203 may be used to communicate with the HTU-C 204 via an xDSL link or EOC 240. The EOC 240 may be a channel on the line pair 202. The test set 220 and modem 203 may also communicate with the HTU-C 204 over a non-xDSL link, such as over the line pair 202.

[0032] A remote termination unit (HTU-R) 234 or modem may be installed at the customer premises 222. However, the HTU-R 234 may not be needed in the embodiment shown in Figure 2 because the test set 220 may include the modem 203 as an integrated or separate component. If the HTU-R 234 is installed, it may be disconnected from the

line pair 202 during line qualification testing by a set of switches 236 or similar devices. The HTU-R 234 may include a microprocessor 242 to control operation of the HTU-R 234 and a memory 244 to store software or computer programs for execution by the microprocessor 242. The HTU-R 234 may also include a transformer 246.

[0033] In one embodiment of the present invention a signal source 250 may be connected to the transformer 246 by a switch 252. The switches 236 and 252 and the signal source 250 enable the HTU-R 234 to function as an FED or the like to test the line pair 202 from the telephone switching office 206 similar to that described with respect to Figure 1.

[0034] Figure 3 is a block diagram of a system 300 to qualify a line pair 302 for DSL, xDSL service or the like in accordance with another embodiment of the present invention. The system 300 may include a far end device (FED) 304 or the like that may be coupled to a main distribution frame (MDF) 306 in the telephone switching office 308 or central office. The FED 304 may be located in a repeater bay of the switching office 308. The FED 304 may be any device to apply different terminations to a line pair, such as an open circuit, a short circuit, a predetermined signal or the

like. The FED 304 may be connectable to a central office termination unit (HTU-C) 310 when needed during the line qualification testing process by operation of switches or relays 312-322. The FED 304 may be a card or circuit board to permit the copper or line qualification testing of line 302 by a single technician at a customer premises 324. A remote termination unit (HTU-R) 326 may be disconnected from the line 302 by switches or relays 328 and a test set 330 may be connected to the line 302 to qualify the line for xDSL operation or the like. The test set 330 may be similar to the test set 120 described with respect to in Figure 1. The HTU-C 310 and FED 304 may each include a microprocessor similar to the microprocessor 108 described with respect to Figure 1. The HTU-C and FED 304 may be programmed to operate in coordination with the copper test set 330 to test the line pair 302 only from the customer premises 324 without the need of assistance from personnel at the telephone switching office 308 or the need to make trips to the switching office 308 to connect and retrieve an FED or the like. With the HTU-C 310 programmed to perform the line qualification testing in coordination with the test set 330 the following tests may be performed: AC/DC foreign voltage, insula-

tion resistance/leakage, capacitive length/balance, load coil detection, longitudinal balance power influence, TDR, wideband noise, insertion loss/slope/loop attenuation (spectral line characterization), metallic impulse noise, return loss and the like. Loop resistance may also be tested with some test compatible HTU-C devices. With the FED 304 the following tests may also be performed: loop resistance (for all manufacturers and models of equipment), longitudinal impulse noise, TDR, return loss from both ends and similar test.

[0035] In one embodiment of the present invention, a common ground connection 324 may be coupled to the input relays or switches 320 and 322 on the HTU-C card or circuit board 310. This may permit resistive balance testing of the line 302 without the need for another tester or person in the switching office 308.

[0036] As previously discussed, the FED 304 under direction of signals from the test set 330 may couple the line 302 to the HTU-C 310 when needed for some span or line qualification tests. Because the FED 304 may allow the copper testing and 'pass-through' to the HTU-C 310 substantially all copper, HDSL, T1 and similar tests on the line 302 may be performed automatically.

[0037] Examples of different methods of operation of the exemplary embodiments illustrated in Figures 1, 2 and 3 will now be described with reference to Figures 4, 5 and 6. Figure 4 is flow chart of a method 400 to qualify a line pair, such as line pair 102, 202 or 302 of Figures 1, 2 or 3 respectively in accordance with an embodiment of the present invention. The method 400 may include a customer premises sequence 402 of actions or events and a telephone switching office or central office sequence 404 of actions or events. An xDSL link or the like may be active in block 406. In block 408, a test set similar to test set 120 of Figure 1 may be connected to a termination unit (HTU-R) similar to HTU-R 120. In an alternative embodiment, an HTU-R similar to HTU-R 234 (Figure 2) may be disconnected from the line pair and a test set with an xDSL modem similar to test set 220 and modem 203 may be connected to the line pair 202. As previously described, the modem 203 may be integrally formed as part of the test set 220. In block 410, an "initiate test" signal may be sent to the HTU-C, such as HTU-C 104, 204 or 310 in Figures 1, 2 and 3 respectively, via an xDSL link 140 or 240, such as a embedded operations channel (EOC) or the like. In block 412, the HTU-C receives the

"initiate test" signal that instructs the HTU-C to start the test sequence. As previously described, the HTU-C may be adapted or programmed to provide selected types of terminations connectable to the line pair to perform the line qualifying tests. The selected types of terminations may include an open circuit, a short circuit and a signal source capable of transmitting a signal of known characteristics on the line pair for testing by the test set at the other end of the line pair. In block 414, the HTU-R may be disconnected from the line pair automatically or manually by a technician, if the HTU-R is not already disconnected from the line pair in block 408.

[0038] In block 416, battery may be removed from the line pair or pairs to be tested and the line pairs may be opened for a predetermined period of time by the HTU-C in block 418. As previously described with respect to Figures 1 and 2, the line pair 102 or 202 may be open circuited or terminated by an open by the HTU-C operating switches 112 (Figure 1) or 212 (Figure 2) to an open position. In block 420, open circuit line qualifying tests may be performed by the test set located at the customer's premises in response to the open line pair or pairs. The open circuit line qualifying tests may include time domain reflectometer

(TDR) tests or measurements, signal leakage tests or measurements, capacitance measurements and noise tests.

[0039] In block 422, the line pair or pairs may be short circuited or terminated by a short circuit by the HTU-C for a predetermined time period. As previously discussed with respect to Figures 1 and 2, the line pair 102 or 202 may be connected to the transformer 116 (Figure 1) or 216 (Figure 2) to provide a short circuit termination through the coils of the transformer 116 or 216. In block 424, short circuit line qualifying tests may be performed on the line pair or pairs by the test set at the customer premises in response to the short circuit termination. The short circuit tests may include loop resistance measurements and resistive balance tests or measurements.

[0040] In block 426, the HTU-C may connect the line pair or pairs to a signal source to transmit a selected signal for a predetermined time period on the line pair or pairs. As previously discussed with respect to Figures 1, the HTU-C 104 may be adapted or programmed to operate switches 112 and 114 to connect the signal source 118 to the line pair 102 to transmit a predetermined signal on the line pair 102. Similarly, in Figure 2, the HTU-C 204 may be

adapted or programmed to operate switches 212 and 214 to connect the signal source 218 to the line pair 202 to transmit a predetermined signal on the line pair 202. In block 428, signal loop tests may be performed on the line pair by the test set in response to the selected signal being transmitted on the line pair or pairs. The signal loop test may include loop attenuation tests, spectral shape measurements, and longitudinal balance measurements.

[0041] In block 430, the predetermined signal may be disconnected from the line pair or pairs by the HTU-C. In block 432, the test set may be disconnected from the line pair or pairs and the HTU-R may be reconnected to the line pair. The battery may be reconnected to the line pair or pairs in block 434 and the xDSL link may be activated in block 436. The xDSL link may then be re-established between the customer premises and switching office in block 438.

[0042] Figure 5 is a flow chart of a method 500 to qualify a line pair in accordance with another embodiment of the present invention. The method 500 includes a sequence 502 of actions or events that occur at a customer's premises and a sequence 504 of actions or events that occur at a telephone switching office or central office. In

block 506, the xDSL link may be inactive. In block 508, an HTU-R may be disconnected from the line pair, if installed, and a test set with an xDSL type modem may be connected to the line pair. An "initiate test" signal may be sent from the test set to the HTU-C via a non-xDSL link, such as the line pair, in block 510. In block 512, the HTU-C may receive the "initiate test" signal to start the test sequence.

[0043] In block 514, the line pair may be open circuited for a predetermined time period. The line pair may be open circuited by the HTU-C as previously described with respect to Figures 1 and 2. In block 516, open circuit line qualification tests may be performed on the line pair by the test set similar to that previously described. In block 518, the line pair may be shorted for a predetermined time period by the HTU-C similar to that previously described. Short circuit tests may be performed on the line pair by the test set in block 520.

[0044] In block 522, the line pair may be terminated by a signal source to transmit a selected signal for a predetermined time period on the line pair. While the predetermined signal is being transmitted on the line pair, signal loop tests may be performed on the line pair in block 528. The sig-

nal loop test may be conducted by the test set similar to that previously described. The test set may be disconnected from the line pair and the HTU-R may be reconnected or installed in block 532. The xDSL link may be activated in block 530 and the xDSL link between the customer premises and the switching office may be established in block 538.

[0045] Figure 6 is a flow chart of a method 600 to qualify a line pair in accordance with a further embodiment of the present invention. In method 600, the test set may be located at either end of the line pair or pairs and the termination unit (HTU), modem or similar device at the other end may be adapted or programmed to provide the selected terminations to conduct the line qualification tests. Similarly, the methods described with respect the Figures 4 and 5 may be modified so that the test set may perform the line qualification tests from either the customer premises or the telephone switching office. The HTU-R, remote modem or similar device may be modified to provide the appropriate terminations to conduct the line qualification tests from the telephone switching office.

[0046] The method 600 may include a sequence 602 of actions or events that occur at one end of a line pair or pairs and

another sequence 604 of actions or events that occur at the other end of the line pair or pairs. Block 606 assumes that an xDSL link may be active between the one end and the other end of the line pair. Although the xDSL link may also be inactive or not yet installed. In block 608, a test set may be connected to an HTU, modem or similar device at one end of the line pair or pairs. In an alternate embodiment, the HTU or modem, if installed, may be disconnected from the line pair and a test set with an associated xDSL modem or the like may be connected to the line pair. The modem may be integrally formed with the test set or may be a separate component.

[0047] In block 610, a first predetermined signal may be sent to the HTU at the other end of the line pair. The test set may be adapted or programmed to send the first predetermined signal in response to a technician entering a code or instruction into the test set. The signal may be sent over an xDSL link, such as an EOC, or the signal may be sent over a non-xDSL link, such as the line pair, and may be an analog signal. In block 612, battery or power may be disconnected from the line pair if the xDSL link is active in block 606 in response to the first predetermined signal or another signal. The battery may be disconnected

from the line pair by the HTU or modem at the other end of the line pair in response to the HTU receiving the first predetermined signal or the other signal if battery is connected to the line pair. A microprocessor in the HTU may be adapted or programmed to disconnect the battery by operating switches or relays similar to that previously described.

[0048] The HTU at the other end of the line pair may open the line pair or connect an open circuit termination to the line pair in response to receiving the first predetermined signal in block 614. A microprocessor in the HTU may cause switches to operate similar to that previously described to open the line pair. In block 616, the test set may detect the open line pair and begin to perform open circuit line qualifying tests on the line pair. Alternatively, the test set may be programmed to begin the open circuit line tests a chosen time delay after sending the first predetermined signal to provide the HTU at the other end adequate time to open circuit the line pair.

[0049] A second predetermined signal may be sent to the HTU at the other end of the line pair in block 618. The test set may be adapted or programmed to also send the second predetermined signal automatically after performing the

open circuit line tests. In an alternate embodiment, a technician may enter a code or the like into the test set to send the second predetermined signal. The HTU at the other end of the line pair may be programmed to short the line pair or to connect the line pair to a short circuit termination in response to receiving the second predetermined signal. The microprocessor in the HTU may be programmed to operate switches to connect the line pair to a transformer to provide the short circuit termination as previously described. In block 622, the short circuit may be detected by the test set at the one end and the test set may begin to perform short circuit line qualification tests in response to detecting the short circuit on the line pair. In an alternative embodiment, the test set may be programmed to begin the short circuit line tests a chosen time period after sending the second predetermined signal to provide the HTU at the other end of the line pair adequate time to short circuit the line pair.

[0050] After performing the short circuit line test, the test set may be programmed to automatically send a third predetermined signal to the HTU at the other end in block 624. In an alternate embodiment, a technician may enter a code or the like to cause the test set to send the third

predetermined signal. The HTU at the other end of the line pair may be programmed to automatically connect the line pair to a selected signal or source of a selected signal in response to receiving the third predetermined signal in block 626. In block 628, the test set may be programmed to detect the selected signal and to perform signal loop qualifying tests on the line pair. Alternatively, the test set may be programmed to automatically start performing the signal loop tests a chosen time period after sending the third predetermined signal to provide time for the HTU at the other end to connect the line pair to the source of the selected signal. The line pair may be connected to the signal source by the microprocessor in the HTU causing switches or relays to operated similar to that previously described.

[0051] In block 630, the test set may send a "test complete" signal to the HTU at the other end of the line pair. The test set may be programmed to automatically send the "test complete" signal when all qualification tests are completed or the technician may enter a code or message into the test set to cause the "test complete" signal to be sent. The HTU may be programmed to disconnect the selected signal from the line pair in response to receiving the "test

complete" signal in block 632. In block 634, the test set may be disconnected from the line pair and the HTU at the one end may be reconnected to the line pair or installed. Battery may be reconnected to the line pair in block 636. The battery may be reconnected automatically by the HTU operating switches or the like in response to the HTU receiving the "test complete" signal. The xDSL link may be activated in block 638 and the link re-established or established for the first time between the one end and the other end in block 640.

[0052] Accordingly, the present invention permits line qualification testing by a single technician from only one end of the line pair. Thus multiple trips between a telephone central office and a customer's premises by a technician are eliminated by the present invention. Additionally, the need for more than one person or cooperation from personnel at a telephone central office is also eliminated by the present invention.

[0053] Although specific embodiments have been illustrated and described herein, those of ordinary skill in the art appreciate that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiments shown and that the invention has other appli-

cations in other environments. This application is intended to cover any adaptations or variations of the present invention. The following claims are in no way intended to limit the scope of the invention to the specific embodiments described herein. .